

What is claimed is:

1. A composite metallic ultrafine particle characterized in that a surface of a core metal produced from a metallic salt, a metallic oxide, or a metallic hydroxide and having a particle diameter of 1 to 100 nm is covered with an organic compound including a functional group having chemisorption capability onto said surface of said core metal.

10 2. A composite metallic ultrafine particle according to claim 1, characterized in that:

said core metal includes at least one member selected from the group consisting of Ag, Au, Bi, Co, Cu, Cr, Fe, Ge, In, Ir, Ni, Os, Pd, Pt, Rh, Ru, Si, Sn, Ti, and V; and

15 the amount of organic compound for covering said core metal is 0.01 to 1 molecule, per metal atom on said surface of said core metal.

3. A composite metallic ultrafine particle according to claim 1, characterized in that said organic compound includes an alcoholic hydroxyl group, carboxyl, thiol, amino, or amide group and has four or more carbon atoms.

4. A composite metallic ultrafine particle according to claim 1, characterized in that said metallic salt is carbonate, nitrate, chloride, acetate, formate, citrate, oxalate, urate, phthalate, or a fatty acid salt having four or less carbon atoms.

5. A process for producing composite metallic ultrafine particles, characterized by comprising:

mixing a metallic salt, a metallic oxide, or a metallic hydroxide with an organic compound including a functional group having chemisorption capability onto a surface of a core metal produced from the metallic salt, the metallic oxide, or the metallic hydroxide; and

heating said mixture for reaction.

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6. A process for producing composite metallic ultrafine particles according to claim 5, characterized in that:

said core metal includes at least one member selected from the group consisting of Ag, Au, Bi, Co, Cu, Cr, Fe, Ge, In, Ir, Ni, Os, Pd, Pt, Rh, Ru, Si, Sn, Ti, and V; and

the amount of organic compound for covering said core metal is 0.01 to 1 molecule, per metal atom on said surface of said core metal.

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7. A process for producing composite metallic ultrafine particles according to claim 5, characterized in that said organic compound includes an alcoholic hydroxyl group, carboxyl, thiol, amino, or amide group and has four or more carbon atoms.

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8. A process for producing composite metallic ultrafine particles according to claim 5, characterized in that said metallic salt is carbonate, nitrate, chloride, acetate,

formate, citrate, oxalate, urate, phthalate, or a fatty acid salt having four or less carbon atoms.

9. A process for producing composite metallic ultrafine particles, characterized by comprising:

mixing a metallic salt, a metallic oxide, or a metallic hydroxide with an organic compound including a functional group having chemisorption capability onto a surface of a core metal produced from the metallic salt, the metallic oxide, or the metallic hydroxide; and

heating said mixture under a reflux condition of said organic compound for reaction.

10. A process for producing composite metallic ultrafine particles according to claim 9, characterized in that:

said core metal includes at least one member selected from the group consisting of Ag, Au, Bi, Co, Cu, Cr, Fe, Ge, In, Ir, Ni, Os, Pd, Pt, Rh, Ru, Si, Sn, Ti, and V; and

the amount of organic compound for covering said core metal is 0.01 to 1 molecule, per metal atom on said surface of said core metal.

11. A process for producing composite metallic ultrafine particles according to claim 9, characterized in that said organic compound includes an alcoholic hydroxyl group, carboxyl, thiol, amino, or amide group and has four or more carbon atoms.

12. A process for producing composite metallic ultrafine particles according to claim 9, characterized in that said metallic salt is carbonate, nitrate, chloride, acetate, formate, citrate, oxalate, urate, phthalate, or a fatty acid salt having four or less carbon atoms.

13. A composite metallic ultrafine particle having a structure in which a periphery of a core metal having a diameter of 1 to 100 nm is surrounded by an organic compound including an alcoholic hydroxyl group.

14. A composite metallic ultrafine particle according to claim 13, characterized in that:

said core metal is at least one member selected from the group consisting of Cu, Ag, Au, In, Si, Ti, Ge, Sn, Fe, Co, Ni, Ru, Rh, Pd, Os, Ir, Pt, V, Cr, and Bi; and

said composite metallic ultrafine particle have a metal content of 50 to 95% by weight.

15. A composite metallic ultrafine particle according to claim 13, characterized in that said organic compound including an alcoholic hydroxyl group is a straight-chain or branched-chain alcohol having four or more carbon atoms, or an aromatic compound including a hydroxyl group.

16. A process for producing composite metallic ultrafine particles, characterized by comprising heating an organic compound including an alcoholic hydroxyl group and a metallic

salt as a metal source at a temperature that is not more than a decomposition initiation temperature of said organic compound including an alcoholic hydroxyl group and is not less than a decomposition temperature of said metallic salt.

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17. A process for producing composite metallic ultrafine particles according to claim 16, characterized in that a metallic component in said metal source is at least one member selected from the group consisting of Cu, Ag, Au, In, Si, Ti,
10 Ge, Sn, Fe, Co, Ni, Ru, Rh, Pd, Os, Ir, Pt, V, Cr, and Bi.

18. A process for producing composite metallic ultrafine particles according to claim 16, characterized in that said metallic salt is carbonate, nitrate, chloride, acetate,
15 formate, citrate, oxalate, urate, phthalate, or a fatty acid salt having four or less carbon atoms.

19. A process for producing composite metallic ultrafine particles, characterized by comprising:

20 mixing an organic compound including an alcoholic hydroxyl group with a metallic salt as a metal source;
adding a reducing agent to said mixture; and
heating said mixture for reaction.

25 20. A process for producing composite metallic ultrafine particles according to claim 19, characterized in that a metallic component in said metal source is at least one member selected from the group consisting of Cu, Ag, Au, In, Si, Ti,

Ge, Sn, Fe, Co, Ni, Ru, Rh, Pd, Os, Ir, Pt, V, Cr, and Bi.

21. A process for producing composite metallic ultrafine particles according to claim 19, characterized in that said
5 metallic salt is carbonate, nitrate, chloride, acetate, formate, citrate, oxalate, urate, phthalate, or a fatty acid salt having four or less carbon atoms.

22. A process for producing composite metallic ultrafine
10 particles, characterized by comprising:

dissolving or dispersing a metal source in a hydrophilic nonaqueous solvent to prepare a solution for composite metallic ultrafine particles;

adding, to a hydrophobic nonaqueous solvent, an organic
15 compound including a functional group having chemisorption capability onto a surface of a core metal produced from said metal source, and said solution for composite metallic ultrafine particles to prepare a precursor of ultrafine particles; and

20 adding a reducing agent to reduce said precursor of ultrafine particles.

23. A process for producing composite metallic ultrafine particles according to claim 22, characterized in that an
25 antioxidant is added to said solution for composite metallic ultrafine particles to enhance the stability of a composite metallic ultrafine particle.

24. A process for producing composite metallic ultrafine particles according to claim 23, characterized in that said antioxidant is ascorbic acid or vitamin E.

5 25. A process for producing composite metallic ultrafine particles according to claim 22, characterized in that said metal source is at least one member selected from the group consisting of inorganic metallic salts and organometallic compounds.

10 26. A process for producing composite metallic ultrafine particles according to claim 22, characterized in that said hydrophilic nonaqueous solvent is a ketone or an alcohol having five or less carbon atoms.

15 27. A process for producing composite metallic ultrafine particles according to claim 22, characterized in that said organic compound including a functional group having chemisorption capability onto a surface of said core metal is
20 at least one member selected from the group consisting of higher alcohols having six or more carbon atoms and surface-active agents.

25 28. A process for producing composite metallic ultrafine particles according to claim 22, characterized in that:
citric acid or ascorbic acid is used as said reducing agent; and

the system is gradually heated to a temperature at which

a reduction action is developed.

29. A process for producing composite metallic ultrafine particles according to claim 22, characterized in that said
5 core metal includes at least one member selected from the group consisting of Ag, Au, Bi, Co, Cu, Cr, Fe, Ge, In, Ir, Ni, Os, Pd, Pt, Rh, Ru, Si, Sn, Ti, and V.

30. A process for producing composite metallic ultrafine
10 particles according to claim 22, characterized in that said hydrophobic nonaqueous solvent is at least one member selected from the group consisting of petroleum hydrocarbons and terpenes.

15 31. An apparatus for forming an interconnection, characterized by comprising:

a loading/unloading section having an inlet/outlet port;

a dispersion liquid supply device for supplying a
dispersion liquid of composite metallic ultrafine particles to
20 a surface of a substrate, said dispersion liquid of composite metallic ultrafine particles being prepared by dispersing, in a predetermined solvent, said composite metallic ultrafine particles in which a surface of a core metal is covered with an organic compound including a functional group having
25 chemisorption capability onto said surface of said core metal;

a heating device for heating said substrate to melt the metal particles and bond them to each other;

a polishing device for polishing the surface of said

substrate to remove an excessively deposited metal, and
a cleaning/drying device for cleaning and drying the
polished substrate.

5 32. An apparatus for forming an interconnection
according to claim 31, characterized by further comprising a
supplementary drying device for drying a solvent contained in
said dispersion liquid of composite metallic ultrafine
particles which has been supplied to said surface of said
10 substrate.

 33. An apparatus for forming an interconnection
according to claim 31, characterized by further comprising a
bevel/backside cleaning device for cleaning a peripheral
15 portion and/or a backside surface of said polished substrate.

 34. An apparatus for forming an interconnection
according to claim 31, characterized by comprising a sensor
for measuring a film thickness in at least one of times after
20 evaporation of a solvent contained in said dispersion liquid
of composite metallic ultrafine particles which has been
supplied to said surface of said substrate, after a heating
process in said heating device, and during or after a
polishing process in said polishing device.

25 35. An apparatus for forming an interconnection
according to claim 34, characterized in that said sensor for
measuring a film thickness is provided in a substrate holding

portion in a substrate transfer device for transferring a substrate.

36. An apparatus for forming an interconnection
5 according to claim 31, characterized in that:

pressures in an indoor facility are respectively
controlled in a cleaning division having said
loading/unloading section and a cleaning/drying section
housing said cleaning/drying device, and a treatment division
10 having a dispersion liquid supply section having said
dispersion liquid supply device therein, a heating section
housing said heating device, and a polishing section housing
said polishing device; and

a pressure in said cleaning division is controlled so as
15 to be higher than a pressure in said treatment division.

37. A method for forming an interconnection,
characterized by comprising:

providing a substrate having a fine cavity formed on a
20 surface of said substrate;

supplying a dispersion liquid of composite metallic
ultrafine particles to said surface of said substrate, said
dispersion liquid of composite metallic ultrafine particles
being prepared by dispersing, in a predetermined solvent, said
25 composite metallic ultrafine particles in which a surface of a
core metal is covered with an organic compound including a
functional group having chemisorption capability onto said
surface of said core metal;

heating said substrate to melt the metal particles and
bond them to each other;

polishing said surface of said substrate to remove an
excessively deposited metal; and

5 cleaning and drying the polished substrate.

38. A method for forming an interconnection according to
claim 37, characterized in that a solvent contained in said
dispersion liquid of composite metallic ultrafine particles is
10 evaporated after said dispersion liquid of composite metallic
ultrafine particles is supplied to said surface of said
substrate and before said substrate is heated.

39. A method for forming an interconnection according to
15 claim 38, characterized in that a film thickness is measured
in at least one of times after evaporation of a solvent
contained in said dispersion liquid of composite metallic
ultrafine particles which has been supplied to said surface of
said substrate, after a heating process of said substrate, and
20 during or after a polishing process of said substrate.

40. A method for forming an interconnection according to
claim 39, characterized in that the amount of said dispersion
liquid of composite metallic ultrafine particles to be
25 supplied to said surface of said substrate is controlled based
on measurement results of said film thickness.